5 Management Measure for Restoration of Wetlands and Riparian Areas

This chapter presents supporting information, including management practices, specific implementation examples, and costs and benefits, for the following management measure:

> **Management Measure**
>
> **Promote the restoration of the preexisting functions in damaged and destroyed wetlands and riparian systems, especially in areas where the systems will serve a significant NPS pollution abatement function.**

Healthy wetland and riparian areas can effectively reduce pollutants such as sediment, nitrogen, and phosphorus in storm water. Wetlands and riparian areas also help to lessen flows from storm events and protect downstream areas from impacts such as channel scour, streambank erosion, and fluctuations in temperature and chemical characteristics. When wetlands or riparian areas are degraded or destroyed, the valuable functions they perform are lost. States and tribes can apply this management measure to restore the full range of wetlands and riparian functions in areas where the systems have been degraded or destroyed.

What Is Restoration?

Restoration is defined as the return of an ecosystem to a close approximation of the conditions present prior to disturbance. In restoration, ecological damage to the resource is repaired; both the structure and the functions of the ecosystem are recreated. The goal of restoration is to emulate a natural, functioning, self-regulating system that is integrated with the ecological landscape in which it occurs (USEPA, 1995a). Restored wetlands and riparian areas, like undisturbed ones, remove NPS pollutants from waters that flow through them. Acting as a sink for phosphorus and converting nitrate to nitrogen gas through denitrification are two examples of the important NPS pollution abatement functions performed by wetlands and riparian areas.

Restoration is an integral part of a broad, watershed-based approach for achieving federal, state, and local water resource goals (USEPA, 1995a). A restoration management measure should be used in conjunction with other measures addressing the adjacent land use activities and, in some cases, water activities as well. Restoration of wetlands and riparian areas is a holistic approach to water quality that addresses NPS problems while meeting the goals of the Clean Water Act to protect and restore the chemical, physical, and biological integrity of the nation's waters.

The fundamental goal of wetland or riparian restoration is to return the ecosystem to a condition that resembles the natural predisturbance state as closely as possible. The establishment and achievement of these goals involves consideration of the ecosystem's structure and function on both the local scale and the broader landscape or watershed scale. Proper planning is necessary to set ecological and NPS pollution goals and to ensure that design, implementation, and monitoring of the project are conducted in a timely and cost-efficient manner and that the goals of restoration are met. Monitoring is critical to measure progress toward achieving restoration goals and to verify that the restored site is performing as it should.

Full restoration of complex wetland and riparian functions may be difficult and expensive, depending on site conditions, the complexity of the system to be restored, the availability of native plants, and other factors. The Department of Energy conducted a study examining the economics of wetland creation, restoration, and enhancement (USDOE, 1994). Costs varied widely, ranging from $5 per acre to more than $1.5 million per acre. Cost differences were attributed to target wetland type and to site-specific and project-specific factors that affected the preconstruction, construction, and postconstruction tasks necessary to meet the project goals. Specific practices for restoration must be tailored to the specific ecosystem type, site conditions, and economic parameters. In addition, wetlands restored to aid in reducing NPS pollution to water bodies must be protected from being degraded by NPS pollution impacts.

Restoration projects vary in size, complexity, and cost based on wetland type, sources of degradation, and local watershed conditions. Local experts knowledgeable about restoration and the local ecology should be involved in the planning process. While certain principles apply to all restoration projects, the design and implementation of restoration projects must be tailored to meet the particular circumstances of each project. For example, even though comprehensive monitoring is desirable, it is often not feasible for smaller restoration projects.

The following steps and activities should be considered in the planning and implementation of restoration projects.

Step 1. Conduct a Basic Site Characterization

Site characterization and data collection are important initial steps in any restoration effort. Data on the physical and chemical characteristics of the restoration site and conditions in the surrounding watershed should be collected and analyzed. Both present and historical site conditions should be characterized. Historical data can provide valuable information useful for developing potentially achievable project goals. It is important, at this stage, to compile available data on stressors that could affect restoration efforts such as nonpoint source pollutant loadings, surrounding land use, and hydrologic alterations (hydromodification). Land ownership and regulatory requirements should also be identified.

Information compiled during the site characterization, including both site-specific and watershed-scale data, provides a baseline for developing the restoration design and for evaluating the progress and success of the project.

- *Characterize existing conditions.* Basic site characterization and data collection are important initial steps in planning restoration. Characterization should include information on soil types, watershed features (size, slope, water availability, water quality), existing vegetative cover types, adjacent land uses, projected future land uses, property boundaries, and fish and wildlife habitat.

Take advantage of existing information about the site to be restored. Use of available documentation can save time, energy, and money. At least some background information is likely to be available. Examples of readily available sources of information include national wetland inventory maps, USGS topographic maps, NRCS soil surveys, state wetland maps, aerial photographs, and flood hazard boundary maps. Long-term residents, university libraries, and local private conservation organizations are also good sources of information. Many areas have been previously studied as part of watershed management plans, resource inventories, environmental impact statements, and the like.

Restoration projects provide excellent opportunities to educate the public on the roles of wetlands and riparian areas in protecting water quality.

- *Conduct watershed-scale analysis.* How a wetland or riparian area is situated in a watershed influences its function. It is important to understand what lands drain to a wetland or riparian area and how the ecosystem fits into the watershed. Conditions throughout a watershed can ultimately affect the success of restoration efforts.
- *Identify nature of impairment.* Initial identification of the causes of damage to a degraded wetland or riparian area is necessary to ensure that they are addressed and ameliorated during the restoration process. A thorough analysis of the cause or causes of alterations or impairments is fundamental to identifying management opportunities and constraints and to defining realistic and attainable restoration objectives.

Step 2. Identify Goals for Restoration

Before identifying and selecting restoration techniques, identify specific goals for restoration.

- *Identify pollution abatement functions along with other ecological benefits obtainable through restoration efforts.* Identify the environmental benefits that may be realized as a result of restoring preexisting wetland or riparian area functions. These benefits, such as NPS pollutant abatement, should form the basis for developing restoration goals. Goals are generalized statements about the expected outcome of the project. It is important that the goals are appropriate and obtainable based on project characteristics and constraints. Public involvement in the development of project goals is important. Involving the public not only improves the validity of restoration goals, but also generates interest and support and can be instrumental in finding necessary funding.
- *Develop specific objectives for hydrology, soils, and biota appropriate to the wetland type being restored.* Turn objectives into measurable target criteria that can be monitored to determine the progress of the project.

- *Begin partnership involvement and refine objectives.* Partners can include anyone who has an interest in the watershed. It is important to include all the key interest groups so that you can tap strengths, increase credibility, reduce duplication of efforts, and make optimal use of limited funds. Early consideration of restoration goals, objectives, and scope can assist participants in determining whose interests are affected. Active participants should include all parties necessary to develop and implement solutions to the problems being addressed, as well as those who could impede restoration efforts.
- *Plan to secure necessary permits.* Restoration conducted in, or in contact with, wetlands and other water bodies may be subject to federal, state, and local regulatory programs and requirements. Permit requirements should be determined at an early stage of the restoration process. Based on project goals and the proposed site, requirements established under federal, state, and local regulations may apply. Federal regulations that may apply include the National Environmental Policy Act; Sections 401, 402, and 404 of the Clean Water Act; section 6 of the Endangered Species Act; and section 10 of the Rivers and Harbors Act of 1899.

Step 3. Identify and Select Restoration Techniques

Although addressing on-site conditions is critical to the chemical, physical, and biological restoration of a wetland or riparian area, the focus of management options should include stressors that originate outside the area as well. Management options considered should include techniques applied on-site and in the surrounding watershed that reduce pollutant loadings and allow the restored wetland or riparian area to reach a state of equilibrium in the landscape.

- *Identify methods that allow nature to do the work (passive versus active restoration).* Consider the use of natural or bioengineering methods over typical structural engineering methods.
- *Identify viable best management practices applicable to obtaining restoration goals.* Properly designed and placed BMPs should be implemented to reduce potential impacts to restoration efforts associated with activities or conditions existing within or outside of the restoration site. See the Management Measures for the Protection of Wetlands and Riparian Areas and for Vegetated Treatment Systems for information on the technical implementation and effectiveness of BMPs. Also, identify BMPs to protect adjacent wetlands from impacts during the construction of the restoration project.
- *Evaluate costs and benefits.* Selecting and evaluating restoration efforts must take into account the costs of implementation, operation, and maintenance. A selected technique should be cost-effective and result in environmental benefits.
- *Consider available financial and technical assistance.* Identify programs to help achieve the implementation of restoration efforts. Nonregulatory or regulatory programs, technical assistance, financial assistance, education, training, technology transfer, and demonstrated projects should be considered. More recently, nonprofit groups have emerged as sources of

technical and financial assistance. See Appendix A for examples of programs and sources of technical assistance.

- *Select best combination of restoration options.* Once restoration options have been identified, select the ones that best meet the project goals, benefit the environment, and are within financial means. If more than one restoration strategy seems feasible, consider each alternative carefully before making a final selection. In particular, make sure the benefits and costs are understood fully when choosing an active restoration strategy. In many instances a passive or bioengineered approach might be preferable to or less expensive than an active or structural technique.
- *Assign priorities to restoration efforts.* Limitations of funding and human resources are often an issue for restoration projects. It is important to establish priorities so that time-sensitive projects and efforts providing the greatest returns can be implemented first.
- *Plan for monitoring.* In any restoration effort, monitoring is needed to evaluate progress toward achieving goals. Monitoring should be planned to track the progress of the project and identify potential problems to ensure that progress initially gained is not lost at a later time. Planning for monitoring should begin before the project is implemented and the site's characteristics are modified. The monitoring plan should include all three phases—design, installation, and evaluation.
- *Establish schedule.* Schedule for success. Seasonal variations and upstream BMP implementation schedules should be taken into account when scheduling restoration.
- *Finalize restoration design plan.* Develop a restoration design plan based on information collected and evaluated in the previous steps. The design plan will be used as the blueprint for implementation of the restoration project. Enough flexibility should be included in the plan to allow for modifications or corrections where needed.
- *Secure necessary permits.*
- *Consider using volunteers.*

Step 4. Implement Restoration

Before implementing restoration, the project designer, contractors, and other stakeholders should meet and agree on scheduling, the order of operation, and responsibilities. The potential for delays caused by bad weather or unforeseen construction obstacles should be considered when developing the project schedule. Allowing extra time to address unforeseen problems should improve the potential for successful restoration.

- *Continue public participation.* Stakeholder involvement should begin early in the restoration process and should continue throughout. An effective and inclusive communication strategy ensures that all potential

Riparian Restoration in Arid Lands
Riparian revegetation, which involves planting trees, shrubs, forbs, or grasses to replace species that have been lost, is one of several recovery strategies that have been used to address the decline of riparian ecosystems in the western United States. Other strategies include improving livestock management, installing streambank stabilization structures, and performing upland treatments. Legislation designed to protect riparian areas by establishing requirements to maintain in-stream flows has also been introduced as a means of restoring these arid region ecosystems.
Source: Briggs, 1996b.

participants have an opportunity to become aware of the progress of restoration. As the process evolves, the goals and objectives may change. Changes in goals and objectives should be articulated to stakeholders.

- *Develop community support through publicity and the use of volunteers.*
- *Protect local resources from construction impacts.* Inspect the site during implementation. Have a coordinator on site to ensure plans are followed, to ensure BMPs are working, and to direct voluteers.
- *Be flexible.* Restoration projects are most successful where flexibility allows changes to be made or corrective measures to be implemented if the original design provides inadequate or site conditions change.

Step 5. Monitor for Success

Ensure that monitoring is designed so that progress is ongoing. All restoration projects should include post-project monitoring that evaluates the effectiveness of the restoration effort, and the evaluation technique should be based on the specific project goals and target criteria. Monitoring the results of the restoration effort allows recovery methods to be adjusted for greater effectiveness. In addition, lessons learned from successes and failures can be applied to future efforts.

- *Design data collection plan.* Typical monitoring activities include
  – water quality sampling
  – measurement of water depths
  – measurement of flow rates and flow patterns
  – substrate characterization
  – sediment flux
  – vegetation characterization and success rates
  – habitat evaluation
  – development of a photographic record
- *Collect and evaluate data.* Progress can be measured in many ways and communicated through meetings, brochures, Internet sites, annual reports, news releases, and other ways. It is important to make sure that the appropriate measures of progress are selected and that information

Save Our Streams (Izaak Walton League)
Through workshops, guides, and a toll-free number, Save Our Streams (SOS) provides technical assistance on restoration and volunteer monitoring techniques to local watershed groups. Training is designed for all age groups. SOS maintains a nationwide computer database of roughly 4,000 projects through which groups can coordinate their efforts with others. Through its hotline SOS refers callers to projects across the nation where similar issues have been tackled and solved. For more information contact

National Save Our Streams (1-800-BUG-IWLA)
http://www.iwla.org

Ask for a copy of SOS's excellent summary of stream restoration resources.

on these indicators is shared with relevant stakeholders. Measurements of progress should be associated with achieving goals set for the restoration effort.

- *Set schedule for continued routine monitoring.* Continued monitoring should be conducted at set intervals that will enable potential problems tobe identified early enough so that corrective measures can be successfully implemented. Routine monitoring should be performed at an appropriate time of year and should be repeated at appropriate intervals to determine whether the project is on track and objectives are being met. Inappropriate timing of monitoring visits can result in a high variability in data. Conduct routine assessment for several years following initial restoration.

Step 6. Long-Term Management

Restoration projects are most successful where long-term management and monitoring are provided. Continued monitoring typically differs from the initial monitoring program, which had the burden of proving that restoration techniques were working in the given setting. Monitoring and assessment should continue for several years and should include water levels throughout the year, establishment of wetland vegetation, patterns of plant succession, development of wetland soil profiles, and use by animal species. Monitoring and assessment should also include conditions in the upstream watershed. Changes in upstream hydrologic conditions resulting from hydromodification or land use changes could adversely affect the success of the restoration project. Identification of changes in the upstream watershed and assessment of their impacts on achieving restoration goals makes it possible to identify and implement design or management changes necessary to ensure the continued success of restoration. Long-term routine monitoring following the completion of initial restoration is designed to identify maintenance needs and to ensure progress toward project goals.

Volunteer monitoring should be considered for tracking the long-term success of the restoration. Volunteers benefit from learning about the characteristics and functions of wetlands and riparian areas, and they can represent a substantial reduction in the often high cost of long-term monitoring.

Key Resources for Promoting Successful Restoration

*A Citizen's Guide to Wetland Restoration: Approaches to Restoring Vegetation Communities and Wildlife Habitat Structure in Freshwater Wetland Sy*stems. 1994. U.S. Environmental Protection Agency, Region 10, Pacific Northwest.

*A Manual for Assessing Restored and Natural Coastal Wetlands with Examples from Southern Cali*fornia. 1990. Pacific Estuarine Research Laboratory, LaJolla, CA. California Sea Grant Report Number T-CSGCP-021.

An Approach to Decision Making in Wetland Restoration and Creation. 1993. Kentula, Brooks, Gwin, Holland, Sherman, Sifneos. CRC Press, Boca Raton, FL.

Ecological Restoration: A Tool to Manage Stream Quality. 1995. U.S. Environmental Protection Agency, Office of Water, Washington, DC. EPA 841-F-95-007.

Goal Setting and Success Criteria for Coastal Habitat Restoration (compilation of papers and abstracts). 1998. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Habitat Conservation, Silver Spring, MD.

Guide to Bottomland Hardwood Restoration. 1999. J.A. Allen, B.D. Keeland, A. Clewell, and H. Kennedy. U.S. Geological Survey.

Guidelines for the Conservation and Restoration of Seasgrasses in the US and Adjacent Waters. 1999. Fonseca, Kenworthy, and Thayer.

Illinois Wetland Restoration and Creation Guide. 1997. A.N. Admiraal, J.M. Morris, T.C. Brooks, J.W. Olson, and M.V. Miller. Illinois Natural History Survey, Champaign, Illinois. Special Publication 19.

*The Keystone National Policy Dialogue on Ecosystem Manag*ement. 1996, The Keystone Center, Keystone, CO. Report No. 6.

Living With Michigan's Wetlands: A Landowner's Guide. 1996. W. Cwikiel. Tipp of the Mitt Watershed Council, Conway, MI.

Living With Michigan's Wetlands: A Landowner's Guide. 1996-1997. U.S. Environmental Protection Agency, Washington, DC.

Managing Your Restored Wetland. 1996. Pennsylvania State University College of Agricultural Sciences, Cooperative Extension.

Minnesota Wetland Restoration Guide: Minneapolis, Minn. 1992. T. A. Wenzel. Minnesota Board of Water and Soil Resources.

National Review of Corps Environmental Restoration Projects. 1995. CORPS. Evaluation of Environmental Investments Research Program. IWR Report 95-R-12.

Northern Prairie Science Center and the Midcontinent Ecological Science Center. <http://www.npwrc.usgs.gov/resource/literatr/wetresto/wetresto.htm > A searchable wetland restoration bibliography with more than 3,000 entries, developed by the Northern Prairie Science Center and the Midcontinent Ecological Science Center.

Our National Wetland Heritage: A Protection Guide. 1996. M.K. Briggs. University of Arizona Press, Tucson.

*Planning Aquatic Ecosystem Restoration Monitoring Pro*grams. 1996. Institute for Water Resources, U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS. IWR Report 96-R-*23*

Planning and Evaluating Restoration of Aquatic Habitats from an Ecological Perspective. 1996. D. Yozzo, J. Titre, and J. Sexton. Institute for Water Resources, U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS. IWR Report 96-EL-4.

Principles for the Ecological Restoration of Aquatic Resources. 2000. U.S. Environmental Protection Agency, Office of Water, Washington, DC. EPA 841-F-00-003.

Protecting Coastal and Wetlands Resources. 1992. U.S. Environmental Protection Agency, Office of Water, Washington, DC. EPA 842-R-92-002.

Riparian Ecosystem Recovery in Arid Lands: Strategies and References. 1996. M.K. Briggs. University of Arizona Press, Tucson.

Restoration of Aquatic Ecosystems - Science, Technology, and Public Policy. 1992. National Research Council Committee on Restoration of Aquatic Ecosystems. National Academy Press, Washington, DC.

Restoring and Creating Wetlands: a Planning Guide for the Central States Region: Iowa, Kansas, Missouri, and Nebraska. 1992. U.S. Environmental Protection Agency, Region 7, Kansas City, KS.

Restoring Prairie Wetlands: An Ecological Approach. 1994. S. M. Galatowitsch and A.G. van der Valk. Iowa State University Press, Ames, Iowa.

Stream Corridor Restoration: Principles, Processes, and Practices. 1998. Federal Interagency Stream Restoration Working Group. U.S. Environmental Protection Agency, Washington, DC. EPA 841-R-98-900.

Top Ten Watershed Lessons Learned. 1998. U.S. Environmental Protection Agency, Office of Water, Washington, DC. EPA 840-F-97-001.

Volunteer Monitoring

Across the country, private citizens are learning about water quality issues and helping protect our nation's water resources by becoming volunteer monitors. Volunteers benefit from learning more about their local water resources, identifying what conditions or activities might be contributing to pollution problems, and working with clubs, environmental groups, and state or local governments to address problem areas. Volunteer monitoring can also be a valuable tool for tracking the success of restoration projects and an effective way of reducing overall costs. EPA's Office of Water maintains an Internet site on the activities of volunteer groups in monitoring surface waters and selected natural resources.

Source: USEPA, 2000b.

Minimal maintenance activities are often required to ensure success. Typical maintenance activities include maintaining buffer zones, preventing soil erosion and sedimentation, inspecting and nurturing plantings and controlling exotic species.

5.1 Management Practices for Restoration of Wetlands and Riparian Areas

The management measure generally will be implemented by applying one or more management practices appropriate to the source, location, and climate. The three management practices described can be applied successfully to implement the management measure for restoring wetlands and riparian areas.

5.1.1 Restoration Project Location

Practice

Plan restoration adjacent to or as part of naturally occurring aquatic ecosystems.

Factor in ecological principles when selecting sites and designing restoration. Restoration goals for a particular project site should be based on an assessment of the condition of the surrounding landscape. The assessment will produce information that can be used to prioritize where specific management practices can achieve desired performance. The information can also be used to establish environmental benchmarks applicable to performance evaluations.

Planning to restore wetlands includes the following:

- Conduct synoptic assessment (Leibowitz et al., 1992) and/or watershed analysis (Montgomery et al., 1995) to establish restoration goals for a geographic area. For example, the opportunity for gaining NPS benefits from a wetland or riparian restoration project may tend to be greater in one area than in another.
- Consider the role of site restoration within a broader context, such as on a landscape scale.
- Characterize reference sites within priority watersheds to establish environmental benchmarks. The benchmarks are used to evaluate the performance of management practices.

Watershed Restoration at Pike Run in Pennsylvania

A restoration project in Pennsylvania demonstrates the effectiveness of including habitat restoration techniques in a watershed treatment program. Restoring riparian areas and wetlands benefits landowners by providing direct economic gain through increased land values, and by providing excellent habitat for a variety of wildlife. Almost 22 miles of riparian restoration has been completed, a total of 40 wetland acres have been restored by fencing cattle out of degraded wetlands, and approximately 1,000 acres of native warm season grasses have been planted. The project included broad-based partnerships among the Fish and Wildlife Service, EPA, Natural Resources Conservation Service, Ducks Unlimited, Pennsylvania Game Commission, Audubon Society, and many other public and private partnerships under the Partners For Wildlife and Clean Water Act section 319 nonpoint source programs.

Source: USEPA and USDA, 1998.

- Depict a set of generally applicable practices for a specific geographic area watershed analysis. The practices are used to promote the development and understanding of a community-based strategy for controlling NPS pollution. For example, look for opportunities to include habitat restoration techniques such as maximizing connectedness, providing refuge for wildlife, and offering recreational amenities to the community.Set goals for the restoration project based on location and type of NPS pollution problem.
- Restoration sites near or connected to similar habitat have the best chance of succeeding. At these sites, it is easier to restore hydrology, soils might already have wetland characteristics, and native wetland species do not have far to travel to reach the site.
- Establish a citizen-based monitoring program that involves the community in NPS pollution control. Information gathered from the monitoring can be used to refine the future application of management practices.

Restoration goals for a particular project site should be based on an assessment of the condition of the surrounding landscape.

Examples of wetland and riparian area restoration are presented in Table 5-1 and Appendix F. Appendix A and Appendix F include examples of sederal, state, and local programs to promote and implement restoration activities.

American Rivers 1997 Urban Hometown River Award:
Earth Conservation Corps—Eagle and Salmon Corps

The Earth Conservation Corps works with disadvantaged young men and women to restore riparian habitats damaged by overuse, degradation, and pollution. In the process, members gain life and job skills that enable them to enter the workforce in the conservation field. Eagle Corps volunteers were chosen from local public housing communities in Washington, DC, in cooperation with the DC Housing Authority. Volunteers work to enhance the water quality of the Anacostia River and create viable bald eagle habitat by restoring natural areas along the river and sponsoring river cleanups to remove solid waste from tributaries. Salmon Corps members are predominantly from five Native American tribes in the Columbia and Snake river regions of the Pacific Northwest. Corps volunteers have enhanced salmon habitats in the five tribal areas by planting riparian vegetation, restoring stream channels, and building in-stream structures. They have erected pole fences to restrict livestock access to salmon habitat and removed trash and debris from spawning beds. For more information contact:

Earth Conservation Corps
Phone: (202) 554-1960, Fax: (202) 554-5060
<http://www.earthconcorps.org/index.htm>
Source: American Rivers, 1998.

5.1.2 Hydrogeomorphic Regime

Practice

Provide a hydrogeomorphic regime similar to that of the type of wetland or riparian area being restored.

Hydrologic and geomorphic conditions are responsible for maintaining many of the functional aspects of wetland ecosystems. These controls are important for such functions as the chemical characteristics of water, habitat maintenance, and water storage and transport. To ensure that restoration goals are achieved, preexisting, existing, and future hydrogeomorphic conditions must be fully understood, thoroughly considered, and carefully incorporated into a design plan for a wetland or riparian area restoration project.

Restoration of hydrology is a critical factor to gain NPS pollution abatement benefits and to increase the probability of successful restoration.

The following are suggestions for implementing this practice:

- *Site history.* Know the past and projected uses of the site, including past wetland or riparian area functions.
- *Topography.* Map the surface topography, including slope and relief of the existing land surface.
- *Tide.* Determine the mean and maximum tidal range, if applicable.
- *Existing water control structures.* Identify the location of culverts, flow control structures, pumps, and outlets.
- *Hydrology.* Investigate the hydrologic conditions affecting the site: wave climate, currents, overland flows, groundwater dynamics, and flood events.
- *Sediment budgets.* Understand the rates and paths of sediment inflow, outflow, and retention.
- *Soil.* Describe the existing soils, including their suitability for supporting wetland plants.
- *Plants.* Identify the existing and, if different, native vegetation.
- *Salinity.* Measure the existing or determine the planned salinity levels at the site, if applicable.

Table 4-4 provides examples of differences in hydrogeomorphic characteristics of several wetland types typically found in the United States. An understanding of these differences is essential in the development of a restoration plan. It is important to note that based on the current state-of-the-science, many of the wetland types described in Table 4-4 should be considered difficult to restore to a fully functional condition. Although it is important to protect all wetlands, emphasis should be placed on protecting those wetland types or wetlands located in areas that are known to be difficult to restore or have a low success rate for restoration.

5.1.3 Restoration of Soils and Plants

Practice

Restore native plant species and soil substrate through either natural succession or the introduction of plant and soil materials.

When consistent with preexisting conditions, plant a diversity of plant types or manage natural succession of diverse plant types rather than planting monocultures. Deeply rooted plants may work better than certain grasses for transforming nitrogen because the roots will reach the water moving below the surface of the soil. Vegetation has been recognized as a major tool to use in soil and water conservation to address water quality problems. For forested systems, a simple approach to successional restoration would be to plant one native tree species, one shrub species, and one ground-cover species and then allow natural succession to add a diversity of native species over time, where appropriate and warranted by target community composition and anticipated successional development. Table 5-2 contains information resources for wetland and riparian area plants.

Information on native plant species is available from federal agencies (NRCS, U.S. Fish and Wildlife Service, etc.), or various state or local agencies, such as the local Cooperative Extension Service office or state departments of agriculture or natural resources.

In drier climates, depth to water table is a critical factor when planning the restoration of riparian areas. For many projects, use of an irrigation system for one or more growing seasons might be required to get the roots of plant material down to the water table (Carothers and Mills, 1990).

The amount of soil organic matter in wetland soils plays a critical role in the function of a wetland, as well as its potential for restoration. In particular, the amount of soil organic matter in wetland soils plays a critical role in nutrient cycling and pollutant detoxification, provides substrate for essential microbes, and influences the development of wetland vegetation. Careful consideration should be given to whether the amount of organic matter at a project site can be increased through properly timed soil amendments and nutrient applications.

5.2 Cost and Benefits of Practices

This section describes the economic benefits of restoring wetlands and riparian areas that serve NPS functions. This information is intended to demonstrate the cost savings accrued by implementing the management measure as compared to the costs of not implementing it. Across the continental United States, the costs of wetland creation and restoration projects vary from $5 per acre to $1.5 million per acre. For those projects not involving the conversion of agricultural land, the average project costs range from $20,000 to more than $75,000 per acre (U.S. DOE, 1994). Because of the wide diversity of regions throughout the United States, no single cost or economic benefit can be used across the board. Instead, the information provided below and in Table 5-3 reflects examples of such costs and benefits in specific areas of the country.

- In response to concerns from citizen groups about degrading streams, state and local governments in Maryland spent $20,000 to $50,000 per housing lot in some areas to repair damaged streams and restore riparian forests. This project was funded by the two counties in the Rock Creek watershed—Montgomery and Prince George's—and by the Maryland Department of the Environment. Total project costs were $2.2 million (NRDC, 1999).
- Vegetative seedings are a common way to stabilize or enhance shoreline. Prairie Restorations, Inc. (2000) estimates vegetative plantings cost from $2,600 to $9,150 per acre. Using a minimal mix of plant varieties, site preparation, materials, seeding, and first year maintenance cost an average of $2,950 per acre.

Federal wetland policies during the past decade have increasingly emphasized restoration of wetland areas. Much of this restoration occurs as part of efforts to mitigate the loss of wetlands at other sites.

Recent studies indicate that it might take decades for soil organic matter to accumulate in projects to levels comparable with those in similar, naturally occurring wetlands (USEPA, 1994c).

Wetland Reconstruction
The City of Des Moines, Washington, is using CW-SRF funds to purchase and reconstruct a badly degraded wetland area and to construct a sediment trap/pond facility. This project is allowing the city to meet two goals it constantly struggles to achieve: flood protection and wetland preservation and enhancement. Area storm water will enter one of two sediment traps by way of the surrounding reconstructed wetlands. The wetlands serve the dual purpose of (1) providing flood protection by collecting storm water runoff and (2) acting as a preliminary filter by removing suspended solids. The majority of sediment removal and any heavy metal removal will occur while the water is in the sediment traps. The water will then leave the traps through artificial inlets that lead to Barnes Creek, which eventually enters Puget Sound. This $222,500 project is part of the National Estuary Program (CWA section 320).
Source: USEPA, 1998c.

5.3 Mitigation Banking

Mitigation banking increasingly is recognized as a means of achieving environmentally and economically sound mitigation for unavoidable and minimized impacts.

Mitigation banking is defined as:

> *Wetland restoration, creation, enhancement, and, in exceptional circumstances, preservation undertaken expressly for the purpose of compensating for unavoidable wetland losses in advance of development actions, when such compensation cannot be achieved at the development site or would not be as environmentally beneficial. (60FR.58605, Nov. 28, 1995).*

Mitigation of proposed actions that would adversely affect wetlands has been a cornerstone of the Clean Water Act section 404 program in recent years. A 1990 memorandum of agreement signed by all the agencies with regulatory responsibilities (USEPA and USACE) outlines a sequence of three steps that must be considered when evaluating an application for a secton 404 permit. First, adverse impacts on wetlands should be avoided when possible; second, when they can not be avoided, impacts should be minimized; and third, where impacts still occur, compensatory mitigation is required. This “sequencing process” is designed to ensure that there is no net loss of wetland functions.

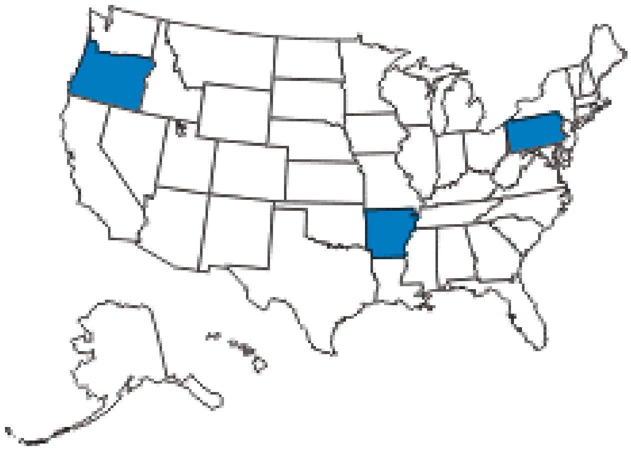
In light of the sequencing and compensatory mitigation requirements under the Clean Water Act Section 404 permit program, the use of mitigation banking is gaining popularity.

Mitigation banking occurs in the context of the wetlands programs established under Clean Water Act section 404, the Rivers and Harbors Act section 10, and the Swampbuster Program under the Food Security Act. Consequently, mitigation banking is to provide for the replacement of the physical, chemical, and biological functions of wetlands that are lost as a result of authorized impacts.

The federal mitigation banking policy and its implementation are described in the *Federal Guidance for the Establishment, Use and Operation of Mitigation Banks* (60 FR 58605, Nov. 28, 1995). The federal guidance lists several advantages of mitigation banking over individual mitigation projects, including the following:

- It may be more advantageous for maintaining the integrity of the aquatic ecosystem to consolidate compensatory mitigation into a single large parcel or contiguous parcels when ecologically appropriate.
- A mitigation bank can bring together financial resources, planning, and scientific expertise not practicable to many project-specific compensatory mitigation proposals.
- Use of mitigation banks may reduce permit processing times and provide more cost-effective compensatory mitigation opportunities.
- Compensatory mitigation is typically implemented and functioning in advance of project impacts, thereby reducing temporal losses of wetland functions and uncertainty over whether mitigation will be successful in offsetting wetland losses.

Table 5-1. Examples of Projects to Restore Wetlands and Riparian Areas



Examples from throughout the United States show the expected cost of many types of wetland and riparian protection projects, as well as their value to the respective communities.

Study Riparian habitat restoration **Type** Riparian Area **Example Project** Eagle River Watershed Wonders, Arkansas
Study Intergovernmental partnership to restore Anacostia River and its tributaries **Type** Wetland **Example Project** Anacostia Watershed Agreement, District of Columbia
Study Restoration of Kenilworth Marsh **Type** Wetland **Example Project** Kenilworth Marsh Restoration, District of Columbia
Study Restoration of emergent freshwater tidal wetlands **Type** Wetland **Example Project** Klingman Lake Restoration Project, District of Columbia
Study Restoration of wetlands to improve water quality in lake **Type** Wetland **Example Project** Upper Klamath Lake, Oregon
Study Watershed treatment through the restoration of wetlands and riparian areas **Type** Wetland and Riparian Areas **Example Project** Pike Run, Pennsylvania

Table 5-2. Examples of Wetland and Riparian Area Plant Informaton Resources

Location	Reference Guide
CA	Mason, H.L. 1957. *A Flora of the Marshes of California*. University of California Press, Berkeley.
FL	• Dressler, R.L., D.W. Hall, K.D. Perkins, N.H. Williams. 1987. *Identification Manual for Wetland Plant Species of Florida*. University of Florida. • Tarver D.P., J.A. Rodgers, M.J. Mahler, and R.L. Lazor 1986. *Aquatic and Wetland Plants of Florida*. Florida DNR.
IL	Winterringer, G.S., and A.C. Lopinot. 1966. *Aquatic Plants of Illinois*. Illinois State Museum Popular Science Series Vol. VI.
IA	Beal, E.O., and P.H. Monson. 1954. Marsh and Aquatic Angiosperms of Iowa. Monocotyledons. Dicotyledons. State University of Iowa. *Studies in Natural History* Vol. 19(5), No. 429.
KY	Beal, E.O., and J.W. Thieret. 1986. *Aquatic and Wetland Plants of Kentucky*. Kentucky Nature Preserves Commission, Frankfort. Scientific and Technical Series No. 5.
LA	Chabreck, R.H., and R.E. Condrey. 1979. *Common Vascular Plants of the Louisiana Marsh*. Louisiana State University, Center for Wetland Resources.
MO	Whitley, J.R., B. Bassett, J.G. Dillard, and R.A. Haefner. 1990. *Water Plants for Missouri Ponds*. Missouri Department of Conservation.
MN	Fink, D.F. 1994. *A Guide to Aquatic Plants: Identification and Management*. Ecological Services Section, Minnesota DNR.
NJ	Fairbrothers, D.E., and E.T. Moul. 1965. *Aquatic Vegetation of New Jersey*. Extension Service, College of Agriculture, Rutgers University.
NC	Beal, E.O. 1977. *A Manual of Marsh and Aquatic Vascular Plants of North Carolina with Habitat Data*. NCSU Agricultural Experiment Station.
SC	Aulbach-Smith, C.A., S.J. de Kozlowski and L.A. Dyck. 1990. *Aquatic and Wetland Plants of South Carolina*. South Carolina Water Resources Commission.
AS, GU, HI, CNMI	Stemmermann, L. 1981. *A Guide to Pacific Wetland Plants*. U.S. Army Corps of Engineers, Honolulu District.
MN and WI	Eggers, S.D., and D. M. Reed. 1997. *Wetland Plants and Communities of Minnesota and Wisconsin*. Published by USACE. <http://www.mvp.usace.army.mil/docs/library/wetform.html>.
OR, WA	Guard, B.J. 1995. *Wetland Plants of Oregon & Washington*. Lone Pine Publishing, Redmond, WA.
TX, CO, KS, NM, OK	Haukos, D.A., and L.M. Smith. 1997. *Common Flora of the Playa Lakes*. Texas Tech University Press, Lubbock. 800/832-4042.
Atlantic Coast	• Eleuterius, L.N. 1990. *Tidal Marsh Plants*. Pelican Publishing Co., Gretna, LA. • Silberhorn, G. 1982. *Common Plants of the Mid-Atlantic Coast: A Field Guide*. Johns Hopkins University Press.
Eastern U.S.	Pierce, R.J. 1977. *Wetland Plants of the Eastern United States*. Army Corps of Engineers, North Atlantic Division, New York.
Midwestern U.S.	USDA. No date. *Midwestern Wetland Flora: Field Office Guide to Plant Species*. Soil Conservation Service, Midwest National Technical Center, Lincoln, NE. Home page of Northern Prairie Wildlife Research Center, Jamestown, ND. <http://www.npwrc.usgs.gov/resource/othrdata/plntguid/plntguid.htm>.
Northern Great Plains	Larson, G.E. 1993. *Aquatic and Wetland Vascular Plants of the Northern Great Plains*. General Technical Report RM-238, Fort Collins, CO. USDA, Forest Service, Rocky Mountain Forest and Range Experiment Station.
Northeastern U.S.	• Hellquist, C.B., and G.E. Crow. 1980. *Aquatic Vascular Plants of New England*. University of New Hampshire Agricultural Experiment Station. • Magee, D.W. 1981. *Freshwater Wetlands: A Guide to Common Indicator Plants of the Northeast*. University of Massachusetts Press. • Tiner, R.W. 1987. *A Field Guide to Coastal Wetland Plants of the Northeastern United States*. University of Massachusetts Press.
Northwestern U.S.	• Steward, A.N., L.J. Dennis, and H.M. Gilkey. 1963. *Aquatic Plants of the Pacific Northwest with Vegetative Keys*. Oregon State University. • Weinmann, F., M. Boule, K. Brunner, J. Malek, and V. Yoshino. 1984. *Wetland Plants of the Pacific Northwest*. USACE, Seattle District.
Southern U.S.	USDA. No date. *Southern Wetland Flora: Field Office Guide to Plant Species*. USDA. South National Technical Center, TX.
Southeastern U.S.	• Eyles, D.E., and J.L. Robertson. 1944. *A Guide and Key to the Aquatic Plants of the Southeastern United States*. Reprint 1963. U.S. Public Health Service, Washington, DC. • Godfrey, R.K., and J.W. Wooten. 1981. *Aquatic and Wetland Plants of Southeastern United States. Dicotyledons*. 1979. *Aquatic and Wetland Plants of Southeastern United States. Monocotyledons*. University of Georgia Press, Athens. • Tiner, R.W. 1993. *Field Guide to Coastal Wetland Plants of the Southeastern United States*. University of Massachusetts Press, Amherst.
Southwestern U.S.	Correll, D.S., and H.B. Correll. 1975. *Aquatic and Wetland Plants of Southwestern United States*. Stanford University Press, California. Vols. 1 and 2.
Western U.S.	USDA. No date. *Western Wetland Flora: Field Office Guide to Plant Species*. Soil Conservation Service, West National Technical Center, Portland, Oregon. Home page of Northern Prairie Wildlife Research Center, Jamestown, ND. <http://www.npwrc.usgs.gov/resource/othrdata/westflor/westflor.htm>.
General Coverage	• Fassett, N.C. 1940. *A Manual of Aquatic Plants*. Reprint 1972. University of Wisconsin Press, Madison. • Hotchkiss, N. 1972. *Common Marsh, Underwater and Floating-leaved Plants of the United States and Canada*. Dover Publications, NY. • Muenscher, W.C. 1944. *Aquatic Plants of the United States*. Comstock Publishing Associates, Cornell University Press, NY. • Tiner, R.W. 1988. *Field Guide to Nontidal Wetland Identification*. Maryland Department of Natural Resources and USFWS. • University of Florida. 1998. *Aquatic Plant Information Retrieval System*. Center for Aquatic and Invasive Plants, University of Florida, Gainesville. <http://aquat1.ifas.ufl.edu/welcome.html>.

Table 5-3. Costs and Economic Benefits Associated with Restoring Wetlands and Riparian Areas

Management measures taken throughout the United States show the expected cost of many types of wetland and riparian protection projects, as well as their value to the respective communities. For many of these projects, the cost to install structural or conventional methods to replace the functions of wetlands have been shown to be much greater than the actual cost of the wetland or riparian protection measure. Results of studies in various states (refer to map graphic) are shown in the table below. Additional information and references about each study cited in the table as provided in Appendix F at the back of the document.

Study Habitat restoration and enhancement **Cost of Conventional Project** **Cost of Restoration** $475,000 (spent from a total of $828,000 budgeted for restoration) **Estimated Benefit to Community** There is an increase in community awareness and appreciation of the environmental and economic benefits of coastal environment restoration **Example Project** Emerson Point Park, Florida
Study Evaluation of wetland creation in former wetland habitat areas **Cost of Conventional Project** **Cost of Restoration** $18,793 per acre **Estimated Benefit to Community** $3,714 per year per acre (recreational benefits) **Example Project** East St. Louis, Illinois
Study Storm water control projects that would have been implemented instead of the streamside greenways or other storm water controls **Cost of Conventional Project** $120 million **Cost of Restoration** $600,000 **Estimated Benefit to Community** $119,400 **Example Project** Johnson County Streamway Park System, Kansas
Study Demonstration project to assist municipalities with planning issues at a watershed level **Cost of Conventional Project** **Cost of Restoration** $10,450 **Estimated Benefit to Community** Fish and wildlife habitat has been restored, wetland habitat have been enhanced, and community awareness and involvement has increased. **Example Project** Buffalo River and Cazenovia Creek Model, New York
Study Riparian restoration to reduce dredging and water treatment costs **Cost of Conventional Project** $1.6 million **Cost of Restoration** $660,000 **Estimated Benefit to Community** $1 million per year **Example Project** Tulatin River, Oregon
Study Partnership to acquire and manage wetlands **Cost of Conventional Project** **Cost of Restoration** **Estimated Benefit to Community** Functions and values of the wetland system in the Willamette Valley will be restored and will benefit the larger ecological community. **Example Project** West Eugene Wetlands Project, Oregon